Ph.D. Registration Research Proposal

On

Hybrid Control Approach Based PID Controller for Process Control Applications

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By

Seema H. Jadhav
Research Scholar

Guide
Dr. R. V. Sarwadnya

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Swami Ramanand Teerth Marathwada University,Nanded.

Department of Instrumentation Engineering,
Shri Guru Gobind Singhji Instiute of Engineering and Technology,
Vishupuri, Nanded,(MS),INDIA.
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Introduction

Control system refers to a single device, or set of devices, that manages, commands, directs or regulates the behaviour of other devices or systems that are used in industrial production for controlling equipment or machines [1].Control systems have been one of the main research focus in academia as well as in the industry for many decades by using some of the control system parameters[2].Whenever these control system parameters are chosen correctly and theoretical design conditions are met then the control strategies have demonstrate satisfactory performance [3].Control system is mainly used in large scale plants which are composed of a variety ofsub processes and sub systems that are typically distribute over vast regions for Process control applications [4].Process control refers to the methods that are used to control process variables when manufacturing a product [5]. For example, factors such as the proportion of one ingredient to another, the temperature of the materials, how well the ingredients are mixed, and the pressure under which the materials are held can significantly impact the quality of an end product [6].Among all of the above precise control of level,temperature, pressure, speed and flow is important in many process applications that refers to the regulation of all aspects of the process [7].

Most industrial processes are controlled by proportional-integral-derivative (PID) controllers. It is a control loop feedback mechanism (controller) commonly used in industrial control systems [8]. A PID controller continuously calculates an error value as the difference between a desired set point and a measured process variable. Usually, a time-consuming iterative manual tuning procedure is required to design these PID controllers [9]. As the name suggests, PID algorithm consists of three basic coefficients; proportional, integral and derivative which are varied to get optimal response [10]. In the PID control system design, three PID control gains, i.e., the proportional gain Kp, integral gain Ki, and derivative gain Kd are required to evaluate the performance [11].It can guarantee the desired control performance of the process and the robustness of the designed controllers to the loop gain variations [12].It is widely used in the

process industries due to its simplicity, robustness and wide ranges of applicability. In addition, the vast majority of the PID controllers do not use derivative action [13].

Conventional PID controllers may not perform well for the complex process, such as the high-order and time delay systems, nonlinear systems, complex and vague systems without precise mathematical models, and systems with uncertainties [14]. It has been found that fuzzy-logic-based PID controllers have better capabilities of handling the aforesaid systems [15]. To improve PID control performance,many researchers have integrated Fuzzy logic Control technique for PID tuning [16].PID tuning is the key issue in the design of PID controllers and most of the tuning processes are implemented manually resulting in difficulty and time consuming [17]. To enhance the capabilities of traditional PID parameters tuning techniques, modern heuristics approaches, such as Genetic Algorithm (GA) and Particle Swarm Optimization (PSO), are employed [18]. However, it has the disadvantage of having poor capacity in dealing with system uncertainties and variations in many complex processes over time [19]. Hence hybrid PID controller approaches provides good parameter tuning along with robust performance of process in terms of time domain specifications, set point tracking, regulatory changes and also provides an optimum stability[20].

Related works

Some of recent research work in the literature related to the PID controller is listed below:-

Das S *et al.*[21] proposed a fractional order (FO) fuzzy Proportional-integral-derivative (PID) controller, which works on the closed loop error and its fractional derivative as the input and has a fractional integrator in its output. The fractional order differ-integrations in the fuzzy logic controller (FLC) were kept as design variables along with the input–output scaling factors (SF) and were optimized with Genetic Algorithm (GA) while minimizing several integral error indices along with the control signal as the objective function. Simulation studies were carried out to control a delayed nonlinear process and an open loop unstable process with time delay. The closed loop performances and controller efforts in each case were compared with conventional PID, fuzzy PID and $PI^{\lambda}D^{\mu}$ controller subjected to different integral performance indices.

Zhang R *et al.*[22]studied the temperature control in an industrial surfactant reactor, where an improved PID controller optimized by extended non-minimal state space model predictive control (ENMSSMPC) framework was employed. The temperature in the surfactant reactor was first modeled as a typical step-response model and then a corresponding improved state space transformation with subsequent MPC design was done. The overall strategy hadcombined the advantages of both PID's simple structure and model predictive control's (MPC's)good control performance. The method was compared with traditional PID and MPC controllers and results showed that it had provided improved performance.

Zhang J *et al.*[23] developed an improved cascade control methodology for superheated processes, in which the primary PID controller was implemented by neural networks trained by minimizing error entropy criterion. The entropy of the tracking error could be estimated recursively by utilizing receding horizon window technique. The measurable disturbances in superheated processes were input to the neuro-PID controller besides the sequences of tracking error in outer loop control system, hence, feedback control was combined with feedforward control in the neuro-PID controller. The convergent condition of the neural networks was analyzed. The implementation procedures of the cascade control approach were summarized. Compared with the neuro-PID controller using minimizing squared error criterion, the neuro-PID controller using minimizing error entropy criterion may decrease fluctuations of the superheated steam temperature.

Powell K M, and Edgar T F [24] proposed a feed forward-plus PID-feedback control scheme to collector field temperature. Feedback PID control was added for reducing steady-state offsets and to account for additional disturbances (e.g. ambient temperature, wind speed, etc.). For a system with storage, the power output was controlled using a PID controller. The PID controllers were tuned using IMC tuning relations. The output power was represented by the flow rate of the saturated steam generated in the boiler. The flow rate was measured and a PID controller was used for controlling it using the flow of stream 2 as a manipulated variable.

Shin H B and Park J G [25] proposed anti-windup PID controller to improve control performance of variable-speed motor drives and was experimentally applied to the speed control of a vector-controlled induction motor driven by a pulse width-modulated voltage source inverter. The steady-state value of the integral state was predicted while the PID controller

output was saturated, and that value was utilized as an initial value of the integral state when the PID controller began to operate in a linear range. Simulation and experiments result in more similar speed responses against load conditions and step reference hav changed over conventional anti-windup schemes. Control performance, such as overshoot and settling time, was very similar to that determined by PID gain in the linear range.

Chen Z *et al.*[26] focused on the design of the Fractional-order PID (FOPID) controller using chaotic non-dominated sorting Genetic Algorithm II (NSGAII) for hydraulic turbine regulating system (HTRS). The parameters chosen of the FOPID controller were formulated as a multi-objective optimization problem, in which the objective functions were composed by the integral of the squared error (ISE) and integral of the time multiplied squared error (ITSE). The chaotic NSGAII algorithm, which was an incorporation of chaotic behaviors into NSGAII, was used as the optimizer to search true Pareto-front of the FOPID controller and designers could implement each of them based on objective functions priority. The designed chaotic NSGAII based FOPID controller procedure was applied to a HTRS system. A comparison study between the optimum integer order PID controller and optimum fractional order PID controller was presented in the paper. The simulation and some experimental results have validated the superiority of the fractional order controllers over the integer controllers.

Zhang R*et al.* [27] proposed a PI controlleroptimized by predictive functional control (PFC) and tested that on liquid level in the industrial coke fractionation tower. Since that kind of process have shown the integrating behavior, a P controllerwas first used for it to generate a self-balancing generalized process, then the PFC based PI control was designed for the generalized process. The resulting controller displays the performance of both PFC and PI control with easy implementation in practice. The performance of the PI controller was compared with traditional PI controller in terms of regulatory/servo set-point tracking, disturbance rejection and measurement noise issues, from which results the PI controller provides better performance.

Hušek P [28] presented a proportional-integral-derivative (PID) controllerdesign procedure for a hydraulic turbine generator governor meeting sensitivity margin specifications. The closed-loop performance was guaranteed over a wide range of operating conditions of the interconnected system. The main advantage was that the simple design, using only one tuning parameter. The

control performance of the method was compared on simulations with the procedure guaranteing gain and phase margins using non-convex optimization.

Rajasekhar A *et al*.[29] proposed the design, implementation and analysis of an integer order (IO) and fractional order (FO) based Proportional Integral Derivative (PID) controller, for speed regulation in a chopper fed Direct Current (DC) motor drive. The interdependent parameters of PID and FOPID controllers were designed in both time and frequency domain. Time domain based design of controllers have focused mainly on minimization of indices like rise time, settling time etc. On the other hand frequency domain based design of controllers focuses on achieving iso damping characteristics. The artificial bee colony (ABC) algorithm enhanced with opposition search has been used to perform the optimization task.

Jung J W *et al.*[30] proposed an adaptive proportional-integral-derivative (PID) speed control scheme for permanent magnet synchronous motor (PMSM) drives. A decoupling term, a PID term, and a supervisory term were three control terms of the controller. The first control term was employed to compensate for the nonlinear factors, the second term was made to automatically adjust the control gains, and the third one was designed to guarantee the system stability. Different from the offline-tuning PID controllers, the adaptive controller possessed adaptive tuning laws to online adjust the control gains based on the gradient descent method. The comparative experiments between the adaptive PID controller and the conventional PID controller were performed on the PMSM drive.

Motivation for the Research

There are numerous control strategies used in control system design as applied in classical control, modern control and intelligent control systems . The new control strategies have been studied, implemented and proposed in many industrial applications. The ideal controller would be robust against parameter variations and lead to better performances. The PID controllers are one of the most popular controllers used in industry because of their remarkable effectiveness, simplicity of implementation and broad applicability. PID controls are widely used as a basic control technology in the industrial control system today for Process control applications such as speed, temperatureand water level control, etc. However, the PID method is not suitable for controlling a system with large amount of lag, parameter variations and uncertainty in models.

The traditional PID controller usually needs some manual tuning before it's used to practical application in industry. Different auto-tuning PID control strategies have been proposed for the complicated systems such as nonlinear system, servo mechanical systems and uncertain spacecraft system, etc. Tuning of PID control systems is not always easy, because of their simple control structures for wide classes of industrial control processes. However, some of the above PID control methods need the knowledge of controlled system model, and some of them lack the stability analysis. In order to avoid this in recent two decades, the PID control has been combined with different methods such as fuzzy control, Genetic Algorithm (GA), robust control and adaptive nonlinear control for controlling some nonlinear systems. Therefore, the trend now a days is to implement hybrid systems consisting of more than one types of approach for process control.

Objective

The major objective of our work is to develop a well suitable hybrid approach for the Process control applications. In this work at first phase we presented a tuning of PID controller for speed control of motors may be DC motor, induction motor etc. DC motor is widely used in industries even ifits maintenance cost is higher than the induction motor. Speed control of motor has attracted considerable research and several methods are developed. The PID controller is the very commonly used compensating controller which is used in nonlinear systems. There are various soft computing techniques which are used for tuning of PID controller to control the speed control of motor. So in order to find optimal solution for the parameter of motor with PID controller optimization techniques such as Genetic Algorithm, Particle Swarm Optimization, Artificial Bee Colony Optimization, Glow worm Swarm optimization techniques can be combined to generate a novel hybrid optimization. The hybrid optimization designed PID controller will be much better in terms of rise time, settling time, overshoot than simple PID controller.

In the second phase of our work we presented a systematic approach for the design and implementation of temperature controller using Intelligent Fuzzy Hybrid PID controller for Temperature control in Process Industry. The Process Industry may be water bath system, oil tank system ,chemical plant, heat exchanger etc. The approach employs PID based intelligent fuzzy-controller with hybrid optimization for determination of the optimal results. It is

anticipated that designing of PID based fuzzy controller would dramatically improves the speed of response of the system, Rise time and settling time would be reduced in magnitude inthe fuzzy scheme as compared with conventional PID controller.

In the last phase of our work we presented a hybrid technique for controlling the water level of a system. Water level control system is required in many industrial processes like water treatment plant, the idea of the process is to keep the tank water level at the desired set point. The proposed hybrid control technique based PID controller will be utilized to maintain the level of water. The hybrid control approach is based on the Adaptive Neuro- Fuzzy Inference System (ANFIS) which is the combination of both Neural network and Fuzzy logic theory. It will inherit the best qualities of both Artificial Intelligence techniques and neglect the drawbacks in them for better performance in the controlling processes. The hybrid ANFIS-PID controller is proposed to eliminate the steady state error, and then it gives more performance and stability. The ANFIS is used for the design of PID controller and the hybrid optimization algorithm is also employed for the optimal selection of PID controller parameters.Therefore, the proposed techniques could tune the PID controller parameters atany other operating condition to improve the transient response of the system. The proposed controller will adjust the output at a level so that there is no error between the sensing value and the set point.

Process Explanation:

PID Controller:

PID controller may be the most widely used controller because of its simplicity and efficiency. The PID controller transfer function, F(s), is:

$$F(s) = K_p\left[1 + \frac{1}{T_i S} + T_d S\right]$$

where: K_p is the proportional gain of the Controller.

K_p / T_i is the integral gain of the controller.

$K_p T_d$ is the differential gain of the controller.

The parameters of the PID controller were tuned using optimization algorithm.

PID controller consists of three terms, namely proportional, integral and derivative control. The combined operation of these three controllers gives control strategy for process control. PID controller manipulates the process variables like pressure, speed, temperature, flow, etc. Some of the applications use PID controllers in cascade networks where two or more PID's are used to achieve control. The structure of PID controller consists of a PID block which gives its output to process block. Process consists of final control devices like motor, heat exchange, water tank, actuators, control valves and other control devices to control various processes of industry. Feedback signal from the process plant is compared with a set point or reference signal and corresponding error signal is fed to the PID. According to the proportional, integral and derivative control, the controller produces combined response or controlled output which is applied to plant control devices.For tuning the PID controller hybrid optimization algorithm is utilized in this research. The tuning of the PID controller is a process of determining the controller parameters, which produce thedesired output, improve robust stabilization, minimize error. The controller tuning involves the selection of optimized values of proportional gain (K_P), integral gain (K_I), and derivative gain (K_D).The subsequent section shows the process flow of the proposed research.

Speed control using Hybrid Optimized PID:

The process needed to be controlled here is the speed of the motor which may be any kind of motor. A block diagram of the speed control using PID controller with hybrid optimization is shown in Figure 1. It consists of the PID controller, Hybrid optimization block, motor and output block. For controlling the speed of motor an error value is calculated which is the difference between measured process variable (PV) and a set point (SP). The controller attempts to minimize the error by adjusting the process control input. The PID controller involves three constant parameters called the proportional (P), integral (I) and derivative (D) values, these values can be interpreted in terms of time. P depends on the present error, I on the accumulation of past error, and D is a prediction of future error, based on current rate of change in speed.The combined operation of these three controllers gives control strategy for speed. The weighted sum of these three actions is used to adjust the process via a hybrid optimization.

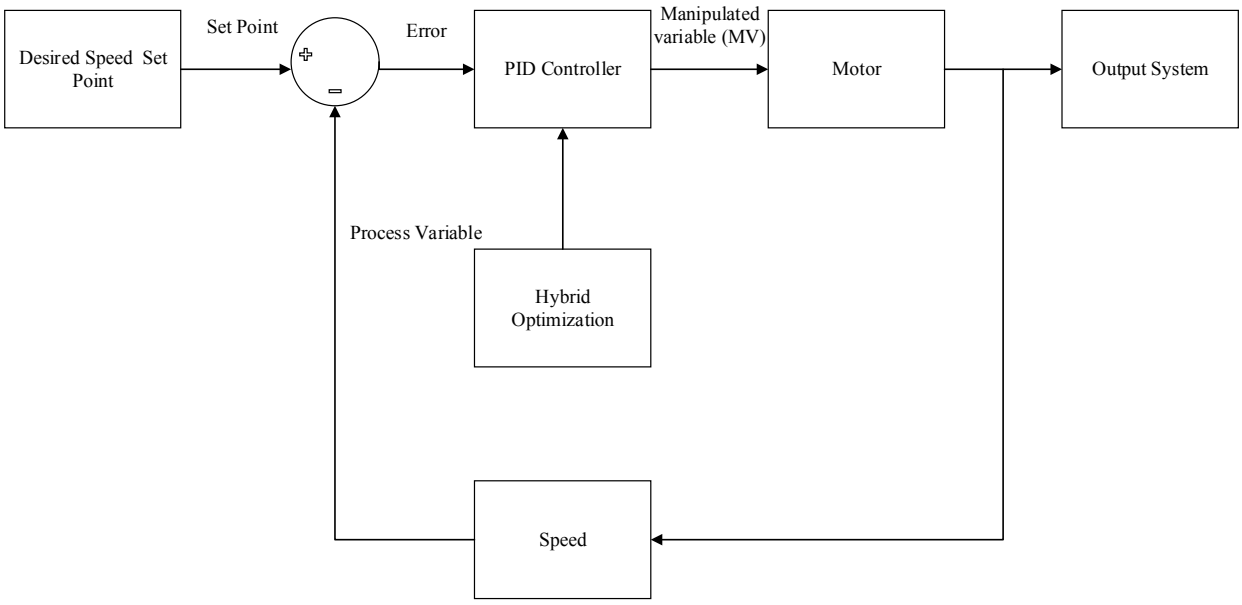

Figure 1:Architecture of Speed Control

Temperature control using Fuzzy PID with Hybrid Optimization:

Temperature control of process industries using Fuzzy PID with Hybrid Optimization is demonstrated in figure 2. The process industries may be water bath system, oil tank system, chemical plant, heat exchanger etc. The fuzzy PID controller is a discrete-time version of the conventional PID controller, which preserves the same linear structure of the proportional, integral, and derivative parts but has constant coefficient yet self-tuned control gains. The constant PID control gains are optimized by using the Hybrid Optimization, there by yieldingan optimal fuzzy PID controller. At first the PID controller takes an error signal as its input and based on that input it will generate a output called either the manipulated variable (MV) or the control variable (CV) and is given to the process at where the temperature control is required.The process will produce the process variable also known as feedback signal which is applied to the comparator, where it is compared with a set point. By comparison the corresponding error signal is generated and fed to the PID controller as an input. This process is repeated iteratively until the error signal nullifies to zero where some set of fuzzy rules are used to adjust the parameters

of PID. Also for the optimal selection of parameters it is necessary to use some of the innovative hybrid optimization algorithms.

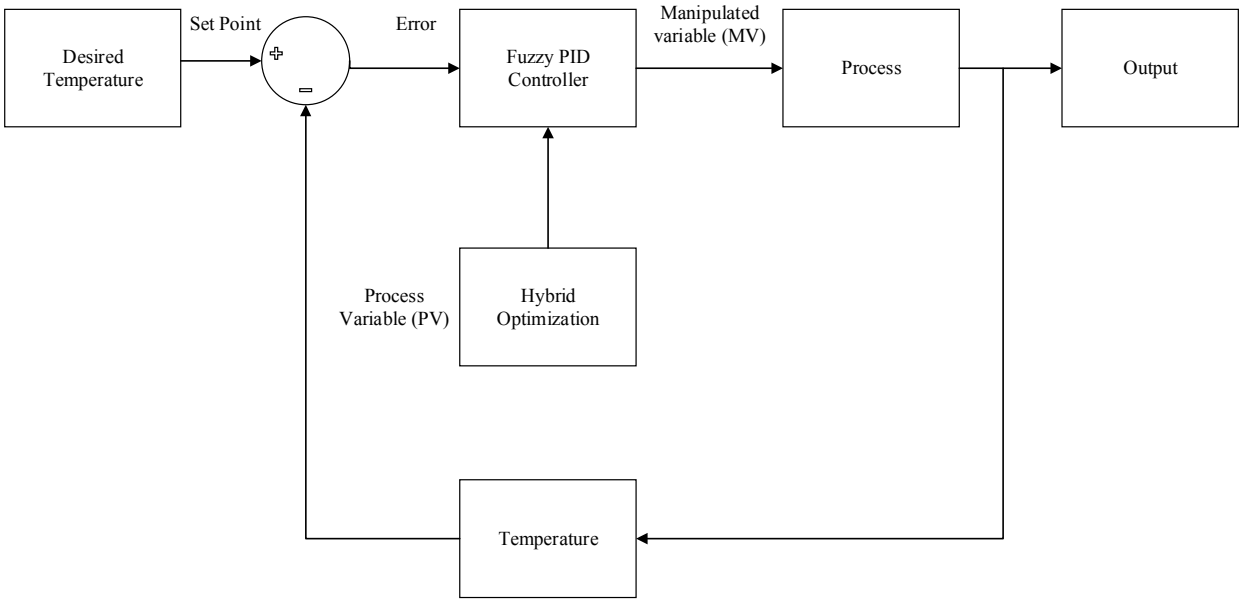

Figure 2:Architecture of temperature control

Water Level control using Adaptive Neuro Fuzzy PID with Hybrid Optimization:

The objectives of this phase is to develop a hybrid controller based on the ANFIS-PID technique. TheHybrid ANFIS-PID controller is combining two controller modes such as PID controller and ANFIS controller. The structure of hybrid ANFIS-PID is shown in Figure 3.

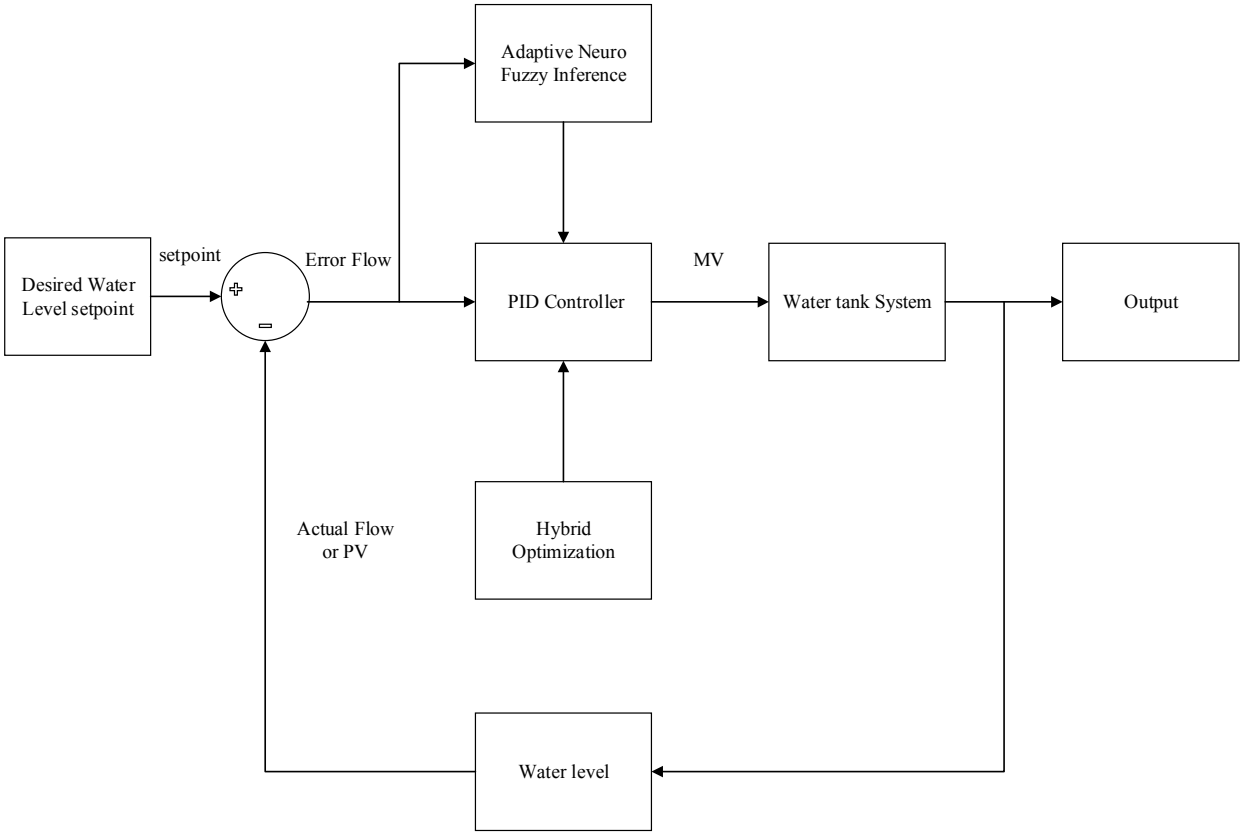

Figure 3:Architecture of water level control

It presents the design of the hybrid PID-ANFIS controller for controlling the water level of the process. The hybrid PID-ANFIS controller is a combination of classical PID controller and ANFIS controller. Hybrid PID-ANFIS controller input consists of water flow setting e.g. set point, actual flow and error flow. The actual flow is acquired by processing the water flow control system. PID controller parameters are tuned using hybrid optimization, while ANFIS controller parameters are acquired by training. The parameters of hybrid PID-ANFIS controller are the combination of the parameter of PID and ANFIS, added by the error limit. These parameters are given to the water flow system. It will generate PV as the actual flow and again the actual flow is compared with the set point to generate error flow. This process is repeated continously until the error flow becomes zero.

Conclusion

Process control is an encouraging research field in control system, because of its wide application. In this work hybrid PID control system will be developed based on artificial

intelligence such as fuzzy logic, neural networks techniques with hybrid optimization techniques. The proposed work will control the processes in large scale industries for controlling speed, temperature, water flow. The proposed works will outcome better stability,Overshoot and settling time so that the process can be optimally controlled. The proposed work will be implemented in the working plat form of Matlab and the performance is proved by the comparison with the conventional PID controller methods. The performance will suggest the effectiveness of the proposed system.

References

[1] Aquino-Lugo A A, Klump R, and Overbye T J, "A control framework for the smart grid for voltage support using agent-based technologies", *IEEE Transactions on Smart Grid*, Vol. 2, No. 1, pp. 173-180, 2011.

[2] Gupta R A, and Chow M Y,"Networked control system: overview and research trends",*IEEE Transactions on Industrial Electronics*, Vol. 57, No. 7, pp. 2527-2535, 2010.

[3] Haber R E, del Toro R M, Gajate A, "Optimal fuzzy control system using the cross-entropy method. A case study of a drilling process", *Information Sciences*, Vol. 180, No. 14, pp. 2777-2792, 2010.

[4]Orihuela L, Millan P, Vivas C, and Rubio F R ,"Distributed control and estimation scheme with applications to process control", *IEEE Transactions on Control systems Technology*, Vol. 23, No. 4, pp. 1563-1570, 2015.

[5] Duflou J R, Sutherland J W, Dornfeld D, Herrmann C, Jeswiet J, Kara S, and Kellens K, "Towards energy and resource efficient manufacturing: A processes and systems approach", *CIRP Annals-Manufacturing Technology*, Vol. 61, No. 2, pp. 587-609, 2012.

[6] Ma Y, Borrelli F, Hencey B, Coffey B, Bengea S, and Haves P, "Model predictive control for the operation of building cooling systems", *IEEE Transactions on Control systems Technology*, Vol. 20, No. 3, pp. 796-803, 2012.

[7] Afram A, and Janabi-Sharifi F, “Theory and applications of HVAC control systems –A review of model predictive control (MPC)”, *Building and Environment*, Vol. 72, pp. 343-355, 2014.

[8] Bevrani H, Hiyama T, and Bevrani H, “Robust PID based power system stabiliser: design and real-time implementation”, *International Journal of Electrical Power & Energy Systems*, Vol. 33, No. 2, pp. 179-188, 2011.

[9] Wei C, and SoffkerD ,“Optimization Strategy for PID-Controller Design of AMB Rotor Systems”, 2015.

[10] Panda S, and Yegireddy N K, “Automatic generation control of multi-area power system using multi-objective non-dominated sorting genetic algorithm-II”, *International Journal of Electrical Power & Energy Systems*, Vol. 53, pp. 54-63, 2013.

[11] Chang W D, and Shih S P, “PID controller design of nonlinear systems using an improved Particle Swarm Optimization approach”, *Communications in Nonlinear Science and Numerical Simulation*, Vol. 15, No. 11, pp. 3632-3639, 2010.

[12] Luo Y, Chen Y Q, Wang C Y, and Pi Y G, “Tuning fractional order proportional integral controllers for fractional order systems”, *Journal of Process Control*, Vol. 20, No. 7, pp. 823-831, 2010.

[13] ShamsuzzohaM and SigurdS "The setpointovershoot method: A simple and fast closed-loop approach for PID tuning" ,*Journal of Process control* , pp. 1220-1234, 2010.

[14] Duan X G, Deng H, and Li H X, “A saturation-based tuning method for fuzzy PID controller”, *IEEE Transactions on Industrial Electronics*, Vol. 60, No. 11, pp. 5177-5185, 2013.

[15] Das S, Pan I, and Das S, “Performance comparison of optimal fractional order hybrid fuzzy PID controllers for handling oscillatory fractional order processes with dead time”, ISA transactions, Vol. 52, No. 4, pp. 550-566, 2013.

[16] Taher S A, Akbari S, Abdolalipour A, and Hematti R, “Robust decentralized controller design for UPFC using μ-synthesis”, *Communications in Nonlinear Science and Numerical Simulation*, Vol. 15, no. 8, pp. 2149-2161, 2010.

[17] Sharkawy A B, “Genetic fuzzy self-tuning PID controllers for antilock braking systems”, *Engineering Applications of Artificial Intelligence*, Vol. 23, No. 7, pp. 1041-1052, 2010.

[18] Fang H, Chen L, and Shen Z, “Application of an improved PSO algorithm to optimal tuning of PID gains for water turbine governor”, *Energy Conversion and Management*, Vol. 52, No. 4, pp. 1763-1770, 2011.

[19] Gédouin P A, Delaleau E, Bourgeot J M, Join C, Chirani S A, and Calloch S, “Experimental comparison of classical pid and model-free control: position control of a shape memory alloy active spring”, *Control Engineering Practice*, Vol. 19, No. 5, pp. 433-441, 2011.

[20] Kim D H, “Hybrid GA–BF based intelligent PID controller tuning for AVR system”, *Applied soft computing*, Vol. 11, No. 1, pp. 11-22, 2011.

[21] Das S, Pan I, Das S, and Gupta A, “A novel fractional order fuzzy PID controller and its optimal time domain tuning based on integral performance indices”,*Engineering Applications of Artificial Intelligence*, Vol. 25, No. 2, pp. 430-442, 2012.

[22] Zhang R, Wu S, Lu R, and Gao F “Predictive control optimization based PID control for temperature in an industrial surfactant reactor”, *Chemometrics and Intelligent Laboratory Systems*, Vol. 135, pp. 48-62, 2014.

[23] Zhang J, Zhang F, Ren M, Hou G, Fang F, “Cascade control of superheated steam temperature with neuro-PID controller”. *ISA transactions*, Vol. 51, No. 6, pp. 778-785, 2012.

[24] Powell K M, and Edgar T F, “Modeling and control of a solar thermal power plant with thermal energy storage”, *Chemical Engineering Science*, Vol. 71, pp. 138-145, 2012.

[25] Shin H B, and Park J G, “Anti-windup PID controller with integral state predictor for variable-speed motor drives”, *IEEE Transactions on Industrial Electronics*, Vol. 59, No. 3, pp. 1509-1516, 2012.

[26] Chen Z, Yuan X, Ji B, Wang P, and Tian H, “Design of a fractional order PID controller for hydraulic turbine regulating system using chaotic non-dominated sorting Genetic Algorithm II”, *Energy Conversion and Management*, Vol. 84, pp. 390-404, 2014.

[27] Zhang R, Wu S, and Gao F, “Improved PI controller based on predictive functional control for liquid level regulation in a coke fractionation tower”, *Journal of Process Control*, Vol. 24, No. 3, pp. 125-132, 2014.

[28] Hušek P, “PID controller design for hydraulic turbine based on sensitivity margin specifications”, *International Journal of Electrical Power & Energy Systems*, Vol. 55, pp. 460-466, 2014.

[29]Rajasekhar A, Jatoth R K, and Abraham A, “Design of intelligent PID/PI λ D μ speed controller for chopper fed DC motor drive using opposition based artificial bee colony algorithm”, *Engineering Applications of Artificial Intelligence*, Vol. 29, pp. 13-32, 2014.

[30] Jung J W, Leu V Q, Do T D, Kim E K, and Choi H H, “Adaptive PID speed control design for permanent magnet synchronous motor drives”, *IEEE Transactions on Power Electronics*, Vol. 30, No. 2, pp. 900-908, 2015.

Research Scholar
Seema H. Jadhav

Research Guide
Dr. R. V. Sarwadnya

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